HAND-OFF METHOD AND MOBILE STATION FOR SPREAD SPECTRUM MOBILE COMMUNICATION

BACKGROUND OF THE INVENTION

The present invention relates to a hand-off method and a mobile station for a spread spectrum cellular mobile communication system.

The cellular mobile communication system is now operational as a digital automobile telephone system. In the digital mobile telephone system, as shown in FIG. **1**A, a service area **1** is split into a plurality of radio zones **2***a*, **2***b*, **2***c*, . . . , which are assigned control channels **3***a*, **3***b*, **3***c*, . . . of individual frequencies, and the control channels **3***a*, **3***b*, **3***c*, . . . are transmitted from radio base stations **4***a*, **4***b*, **4***c*, . . . installed in the radio zones **2***a*, **2***b*, **2***c*, . . . , respectively. When a mobile station **5** hands off during conversation, it measures the received levels of the control channels **3***a*, **3***b*, **3***c*, . . . from the radio zones **2***a*, **2***b*, **2***c*, . . . one after another through utilization of idle time slots I of the TDMA scheme which transmits and receives in specified time slots (Tx) and (Rx) as shown in FIG. **1**B, then compares the measured received levels and selects the radio zone of the maximum received level as a destination or new radio zone.

On the other hand, in the spread spectrum mobile communication system, a single radio frequency is assigned in common to all radio zones involved and a plurality of spectrum spreading codes are assigned to each radio zone; one possible method for hand-off in this system is to scan the spectrum spreading codes by a correlator of the mobile station, select a destination radio zone by measuring and comparing the received levels every radio zone and set the spectrum spreading codes of the destination radio zone in the correlator. In the spread spectrum mobile communication system, however, it is necessary to prepare a wide-band radio frequency channel so that when traffic of the radio zones is unbalanced, many spectrum spreading codes could be used to accommodate or deal with the traffic imbalance; this inevitably leads to overdesign of low-traffic radio zones.

To avoid this, it is possible to employ a system configuration wherein a plurality of radio channels of different frequencies but of the same bandwidth corresponding to a certain traffic volume are prepared, radio zones of low traffic are assigned only one of the radio channels, radio zones of high traffic are assigned two or more of the radio channels and the radio channel of the same frequency is assigned a different spectrum spreading code at least every group of adjacent radio zones. In this instance, each communication channel is defined by a set (f, c) of the radio frequency f and the spectrum spreading code C. In the following description, the channel of the radio **20** frequency f that is assigned one or more spectrum spreading codes will be referred to as a radio channel. Hence, each radio channel is allowed to contain a plurality of communication channels defined by different spectrum spreading codes.

As indicated by the traffic volume distribution curve **6** in FIG. **2**, traffic tends to be high in the central city area but decrease with distance therefrom. In such a situation, the number of radio channels necessary for dealing with traffic is selected large in the central area of the city but smaller with an increase in the distance therefrom as indicated by the channel numbers **F1**, **F2**, **F3**, assigned to the zones **2***a*, **2***b*, **2***c*, . . . in FIG. **2**. To hand off during conversation in this system configuration, the mobile station determines its destination radio zone on the basis of the received level of a

predetermined communication channel (a control channel or broadcasting channel for zone selection use, for example) from every radio zone of the radio channel **F1** of the frequency f common to all radio zones. Accordingly, to select the destination zone during conversation over a radio channel other than the common radio channel **F1** in the radio zone assigned the plurality of radio channels **F1**, **F2**, . . . , it is necessary to measure the received level in the common channel **F1** and this requires interruption of the conversation. To enable measurement of the received level without interrupting the conversation, two receiving systems need to be prepared—this goes against the demand for miniaturization of the mobile station.

A possible solution to the above-noted problem is to employ a TDMA-like radio channel scheme as in the digital automobile telephone system and utilize a TDMA-type idle time slot to detect the destination zone. With this method, however, since signals become burst-like, the electromagnetic compatibility (EMC) of the system must be taken into account, besides guard bits and synchronization words are needed, impairing the efficiency in usage of the channel.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a hand-off method and a mobile station for the spread spectrum mobile communication system which permit hand-off during conversation with no possibility of overdesigning low-traffic radio zones, with no need of preparing two receiving systems and with no fear of incurring the "electromagnetic compatibility" problem.

According to a first aspect of the present invention, a radio frequency is set in common to all radio zones belonging to a service area, the common radio frequency is assigned a spectrum spreading code for control use every radio zone and two correlators are provided in the mobile station. At the hand-off during conversation, one of the correlators is used to scan the spectrum spreading codes and measure the received levels for selecting the destination radio zone, while at the same time the other correlator is used to continue conversation.

According to a second aspect of the present invention, radio channels of a number corresponding to the traffic of each radio zone are assigned to the zone in a predetermined order, and radio channels equal in number to the difference between the largest one of the numbers of radio channels assigned to each zone and adjacent zones and the number of radio channels assigned to each radio zone are provided as hand-off-only channels in each radio zone. Furthermore, those of the assigned radio channels and hand-off-only channels of each radio zone which have the same frequency are assigned spectrum spreading codes which differ with radio zones. The mobile station is equipped with two correlators, one of which is used to scan the spectrum spreading codes and measure the received levels for selecting the destination radio zone and the other of which is used to continue conversation. When the channel held in communication after the hand-off operation is a hand-off-only channel, it is switched to one of the assigned radio channels in the same radio zone.

Thus, according to the first and second aspects of the present invention, the band of each radio channel is determined in accordance with the lowest traffic volume in the radio zones belonging to the service area and each radio zone is assigned radio channels corresponding in number to the traffic of the zone-this permits an economical and hence